

## CONFIRMATION OF ELLIPTICAL MIGRATION IN A POPULATION OF SEMIPALMATED SANDPIPERS

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**ABSTRACT.**—Using measurements and observations of marked birds we verified the elliptical migration route of some Semipalmated Sandpipers. Bill lengths of spring migrants in Saskatchewan averaged longer than those of fall migrants, suggesting a mix of short-billed western and longer-billed central Arctic breeders in the spring, and a greater proportion of western breeders in the fall. A number of birds captured during spring migration in Saskatchewan (presumably central Arctic breeders) were found staging in eastern Canada in the fall. In contrast, no birds captured during fall migration in Saskatchewan were seen north of Maryland on the east coast in the fall. Other Saskatchewan spring migrants (presumably western breeders) returned south through the prairies. These findings emphasize the inter-relatedness of major migratory staging areas during spring and fall migration for this species. Received 9 March 1993, accepted 2 Sept. 1993.

Semipalmated Sandpipers (*Calidris pusilla*) breed across northern Canada and Alaska and winter primarily in northeastern South America (Phillips 1975, AOU 1983, Morrison 1984, Godfrey 1986, Morrison and Ross 1989). Although they are one of the most common shorebirds seen during migration in North America, much remains unknown about the migratory routes and wintering areas of different breeding populations. Measurements of live birds and museum specimens, as well as resightings of birds marked and banded in eastern Canada and the eastern seaboard of the United States, suggest the following migration routes. In the fall, most central and all eastern breeders return south via the Atlantic coast, staging primarily at the Bay of Fundy, Canada. Western breeders apparently migrate south through the interior of North America. In the spring, eastern breeders follow an Atlantic route from northern South America to the eastern United States at Delaware Bay, New Jersey, south of the Bay of Fundy. Central and western arctic breeders appear to migrate north through the interior of North America. Therefore the migration routes of central and eastern breeders follow somewhat of an elliptical pattern, being farther east in the fall than in spring (Harrington and Morrison 1979, Lank 1983, Morrison 1984, Hicklin 1987).

Few banding studies have been carried out in the interior of North America, with the exception of Cheyenne Bottoms, Kansas (Martinez 1979), and Sibley Lake, North Dakota (Lank 1983). Very few resightings of birds banded in these areas have been published, although these records

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have supported the suggested migration routes of fall migrants (Lank 1983, and in Morrison 1984). Almost no information is available on spring migrants in the prairies. Therefore, the purpose of this study is to report measurements and resightings of Semipalmated Sandpipers marked in Saskatchewan during both spring and fall migration, and to determine whether these results support the suggested migration routes for different breeding populations of this species.

#### STUDY AREA AND METHODS

The Quill Lakes in Saskatchewan (54°N, 104°W) consist of a complex of three alkaline lakes with associated marshy wetlands, about 200 km east of Saskatoon. Big Quill Lake is approximately 27 km by 18 km, Middle Quill 6 km by 3 km, and Little Quill 24 km by 3 km. Salinity levels are variable, differing among lakes and water levels (Morrison et al. 1991). Numbers of Semipalmated Sandpipers migrating through the Quill Lakes in the spring and fall appear to vary among years, but range from tens of thousands in the spring to less than five thousand in the fall (unpubl. data).

Shorebirds were captured at Little Quill Lake (LQL) from 1988 to 1992. Since sample sizes are greatest from 1990 to 1992, and measurements were standardized in those years, we present data only from 1990, 1991, and 1992. Spring migrants were caught in 1990 (26 May–1 June) and in 1992 (16 May–3 June). Fall migrants were sampled in 1990 (16 July–23 August) and 1991 (11 July–26 August). All birds were captured with mistnets, primarily at night.

Birds were given a metal band (usually stainless steel), one or two white plastic (darvic) leg flags, and one color band (red or green). Measurements taken included wing length ( $\pm 1$  mm, maximum chord: flattened and straightened) and bill length ( $\pm 0.1$  mm, exposed culmen: feathering to tip). Birds were aged by plumage characteristics (Prater et al. 1977), dyed with a pattern of picric acid (yellow-orange) on their underparts, and released 0.5 to 6 h later (usually <2 h). Sex was determined by internal examination in a small set of birds collected for another study.

CLGT measured virtually all birds in 1990 and 1992, and HLD, GB (G. Beyersbergen) and CLGT all birds in 1991. Several series of birds were measured by these three researchers in 1991 to assess differences in measuring, and all wing lengths were standardized to those of CLGT. The few wing measurements taken by others were not used. Coefficients of variation (CV) were calculated for each season-year-age group (e.g., fall 1990 adults) and compared to each other using the methods described by Dow (1976).

#### RESULTS

*Numbers marked.*—During spring migration, 400 adult Semipalmated Sandpipers were marked in 1990 and 324 in 1992. During fall migration, most Semipalmated Sandpipers captured were juveniles: 30 adults and 1309 juveniles in 1990, 57 adults and 491 juveniles in 1991.

*Spring migrants at Little Quill Lake.*—Sightings of birds marked at LQL during spring migration are shown in Fig. 1 and listed in Table 1. Six birds at LQL during spring migration were observed or banded in South America: five in French Guyana and one in Peru. The remaining reports of birds marked at LQL in spring were seen during fall migration:



three in Ontario and New York, five in the Bay of Fundy and northeast coast of the United States, and four in the interior of North America.

*Fall migrants at Little Quill Lake.*—A number of birds banded during fall at LQL (Table 2, Fig. 2) were seen during late fall and winter near and in wintering areas. Four birds banded as adults were observed in French Guyana, and one banded at LQL as a juvenile was found dead in French Guyana two years later. The adult observed on 8 October 1992 was seen in the same flock as a bird marked at LQL in the spring of 1990 (A. LeDreff). Four more birds were recovered in Guyana: three banded as juveniles and one as an adult. Another bird was seen in Aruba, juveniles in Cuba and Puerto Rico, and an adult was from Venezuela.

Twelve Semipalmated Sandpipers banded at LQL in the fall of 1988 were observed at Iona Island, British Columbia, from 27 June to 1 July 1989 (R. Tootchin). A bird banded as a juvenile was seen at age two with a brood at Prudhoe Bay, Alaska.

During fall migration, two birds (one adult and one yearling banded as a juvenile at LQL) were observed in Tennessee. Seven more birds (four juveniles, three of unknown age) were sighted along the east coast of the United States (Maryland, Virginia, North and South Carolina) later in the same fall that they were banded at LQL.

*Measurements.*—Years were not combined due to significant differences in seasons between years (ANOVA,  $P < 0.05$ ). An analysis of variance for unbalanced data (SAS Institute 1988) demonstrated that year ( $P < 0.0001$ ), season ( $P < 0.03$ ), and age ( $P < 0.02$ ) were all significant effects on wing length, although year appeared most important. However, for bill length, only season was a significant effect ( $P < 0.0001$ ), not year ( $P < 0.19$ ) or age ( $P < 0.95$ ). Therefore, spring and fall birds differed in size, particularly with respect to bill length, with spring migrants averaging larger than those captured in fall (Table 3). Differences between years may be due to varying proportions of each sex.

Coefficients of variation for each season-year-age were compared to each other with respect to wing and bill length (Table 3). Only one comparison of 30 was significant (bill length: 1992 spring adults vs 1990 fall juveniles,  $t = 2.5$ ,  $P < 0.02$ , two-tailed test). Therefore there were virtually no significant differences between seasons in coefficients of variation.

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 FIG. 1. Observations of Semipalmated Sandpipers banded at Little Quill Lake, Saskatchewan, during spring migration. The banding site (May/June) is marked by a star. Birds observed during the fall or winter (July to March) are indicated by full triangles with point downwards, and those seen during spring or summer (April to June) by empty triangles pointing upwards.

TABLE 1  
RESIGHTINGS OF SPRING MIGRANTS FROM LITTLE QUILL LAKE (LQL), SASKATCHEWAN

Banding age/location/date	Observation location/date	Observer or bander
Adult/LQL/May-June 1990	Kourou, French Guyana/1 Oct. 1990	A. LeDreff
Adult/LQL/May-June 1990	Kourou, French Guyana/22-25 Apr. 1991	A. LeDreff
Adult/LQL/May-June 1990	Kourou, French Guyana/19 Sept.-28 Oct. 1991	A. LeDreff
Adult/LQL/May-June 1992	Kourou, French Guyana/8 Oct. 1992	A. LeDreff
Adult/Kourou, French Guyana/26 Oct. 1992	LQL/26 May 1992	A. LeDreff
?/Peru/?	LQL/24 May 1992	G. Beyersbergen
Adult/LQL/May-June 1990	Fall (eastern)	
Adult/LQL/May-June 1992	Montezuma Wildl. Refuge, New York/25 Aug. 1990	G. Wolfred & G. Butcher
Adult/LQL/May-June 1992	Cranberry Marsh, Whitby, Ontario/6-7 Aug. 1992	M. Bain & P. Holder
Adult/LQL/May-June 1990	Ottawa Beach, Ottawa, Ontario/4 Aug. 1992	T. Beck
Adult/LQL/May-June 1990	Grand Manan Is., New Brunswick/6-10 Aug. 1990	L. White
Adult/LQL/May-June 1990	Grand Manan Is., New Brunswick/7 Aug. 1990	L. White
Adult/LQL/May-June 1990	Evangeline Beach, Nova Scotia/14 Aug. 1990	J. Tufts
?/Dorchester Cape, New Brunswick/Fall 1989	LQL/31 May 1990	P. Hicklin
Adult/Stratford Pt., Connecticut/6 Aug. 1984	LQL/27 May 1990	C. Trichka
Adult/LQL/May-June 1990	Fall (central)	
Adult/LQL/May-June 1990	LQL/23 July 1990	P. Chittick
Adult/LQL/May-June 1992	Fargo Sewage Lagoons, North Dakota/22 July 1990	M. Bergen
Adult/LQL/July-Aug. 1988	LQL/24 July 1992	T. Horsley
	LQL/17 May 1990	H. L. Dickson

We also compared measurements of Semipalmated Sandpipers of known sex from LQL (Table 4). Analysis of variance indicated a significant effect of sex on wing length ( $P < 0.03$ ) but no significant effect of season ( $P = 0.14$ ). Analysis of variance on bill length indicated a highly significant effect of sex ( $P < 0.0001$ ) and also a smaller, but significant, effect of season on bill length ( $P < 0.01$ ).

#### DISCUSSION

Observations of Semipalmated Sandpipers marked at LQL support the elliptical migration pattern of central breeders suggested by Harrington and Morrison (1979). Fall migrants from the Quill Lakes area flew south through Tennessee, Maryland, North Carolina, South Carolina, and Virginia, and overwintered in northern South America. The only birds observed in Tennessee were seen as adults, even though many more juveniles than adults were marked during fall migration at LQL, and only juveniles were definitely identified as to age on the southeastern seaboard of the United States. Perhaps adults migrating from Saskatchewan in the fall fly south farther inland than juveniles, which appear to migrate down the coast.

Semipalmated Sandpipers migrating north through the Quill Lakes in spring, flew south either through the interior of North America (Saskatchewan, North Dakota) or farther east (New York, Ontario, New Brunswick, Nova Scotia, Connecticut). Many sightings were considerably farther north and east on the eastern seaboard of the United States and Canada than were those of spring-marked LQL birds. At least some fall LQL birds also wintered in northern South America.

Most Semipalmated Sandpipers winter in northern South America along the coasts of Suriname, Guyana, and French Guyana (Morrison and Ross 1989). Western breeders are thought to winter farther west than eastern and central Arctic birds (Lank 1983, Morrison 1984, see also Resende et al. 1989). We have no evidence that fall migrants at LQL generally winter farther west than spring migrants. However, discovery of marked birds on the wintering grounds is dependant on uneven reporting of band recoveries (primarily Guyana) and distribution of observers (primarily French Guyana at present). More fall-marked LQL birds may winter in northwestern South America but go unreported. Nevertheless, if LQL fall migrants are western breeders, then some western breeders do winter in French Guyana. In fact, a bird banded during spring migration at LQL, and one banded there in the fall, were observed in a single flock in French Guyana (A. LeDreff, pers. comm.).

It is curious, considering that twenty times more juveniles than adults were marked during fall migration at LQL, that four of five LQL birds

TABLE 2  
RESIGHTINGS OF FALL MIGRANTS FROM LITTLE QUILL LAKE (LQL), SASKATCHEWAN

Banding age/location/date	Observation location/date	Observer or bander
Adult/LQL/July-Aug. 1990	Winter	
Adult/LQL/July-Aug. 1990	Kourou, French Guyana/4-19 Sept. 1990	A. LeDreff
Adult/LQL/July-Aug. 1990	Kourou, French Guyana/21 Nov. 1990	A. LeDreff
Adult/LQL/July-Aug. 1991	Kourou, French Guyana/8 Oct. 1992*	A. LeDreff
Adult/LQL/July-Aug. 1989	Kourou, French Guyana/23 Sept.-18 Nov. 1991	A. LeDreff
Adult/Venezuela/?	Georgetown, Guyana/22 Sept. 1991	R. Baksh
?/LQL/July-Aug. 1988	LQL/5 Aug. 1988	H. L. Dickson
Juvenile/LQL/10 Aug. 1990	Aruba/17-19 Sept. 1988	A. Spans
Juvenile/LQL/7 Aug. 1990	Guyana/12 June 1992	J. Chinamootoo and C. Berbice
Juvenile/LQL/5 Aug. 1988	Georgetown, Guyana/9 Sept. 1990	T. Singh
Juvenile/LQL/18 Aug. 1990	Nigg, New Shine, Guyana/17 Oct. 1989	S. Sasmareni and C. Berbice
Juvenile/LQL/19 Aug. 1990	Kourou, French Guyana/28 Sept. 1992	A. LeDreff
Juvenile/LQL/July-Aug. 1991	S. Miguel Parada, Cuba/13 Sept. 1990	L. D. Melian
Juvenile/LQL/18 Aug. 1991	Boqueron, Puerto Rico/2-12 Oct. 1991	B. Harrington
	Wilhelmina Str., Suriname/24 Oct. 1992	R. Mohabir
12 birds/LQL/July-Aug. 1988	Spring/Summer	
Juvenile/LQL/July-Aug. 1990	Iona Is., British Columbia/27 June-1 July 1989	R. Toochin
	Prudhoe Bay, Alaska (with brood)/4 July 1992	D. Troy
Adult/LQL/July-Aug. 1990	Fall	
?/LQL/July-Aug. 1990	Enslay Sewer Lagoons, Memphis, Tennessee/15-17 Aug. 1992	J. Wilson
?/LQL/July-Aug. 1989	Easton Sewage Lagoon, Maryland/15 Sept. 1990	M. O'Brien
?/LQL/July-Aug. 1990	Silver Bluff Plantation, Jackson, South Carolina/2 Aug. 1989	D. Young
Juvenile/LQL/July-Aug. 1991	S. Nags Head Ocean Beach, North Carolina/23 Sept. 1990	R. DeVeau
Juvenile/LQL/July-Aug. 1990	Enslay Sewer Lagoons, Memphis, Tennessee/26 July 1992	J. Wilson
Juvenile/LQL/July-Aug. 1990	Easton Sewage Lagoon, Maryland/11-15 Sept. 1990	M. O'Brien
Juvenile/LQL/July-Aug. 1990	Cape Hatteras Is., South Carolina/24 Sept. 1990	L. Stenzel and G. Page
Juvenile/LQL/July-Aug. 1990	Chincoteague Natl. Wildl. Refuge, Virginia/27 Sept. 1990	L. Stenzel and G. Page
Juvenile/LQL/July-Aug. 1991	Pea Is. Natl. Wildl. Refuge, North Carolina/20 Sept. 1991	S. Dinsmore

\* Seen in same flock as bird marked at LQL in Spring, 1990 (A. LeDreff).

observed in French Guyana were banded as adults. Possibly juveniles and fall adults at LQL are from separate breeding populations, although measurements were not consistently different (Table 3). Perhaps wintering areas differ between adults and juveniles, as migration routes sometimes do (above, and Morrison 1984), since the one bird banded as a juvenile was not recovered in French Guyana until several years later. Semipalmated Sandpipers from western breeding areas may not migrate as far east as adults in northern South America.

Twelve birds banded at LQL during the fall of 1988 were observed near Vancouver, British Columbia, in late June the following year. This is very late for spring migration, since virtually all Semipalmated Sandpipers should have initiated nests by this time (Gratto-Trevor 1992). It is very early for southward migration, even of failed breeders. It is possible that these birds were yearlings, as almost 90% (825/957) of Semipalmated Sandpipers banded at LQL in 1988 were juveniles. This, then, may represent a late or partial northwards migration of nonbreeders. Although some Semipalmated Sandpipers breed as yearlings, most do not migrate or attempt to breed until age two or older (Gratto and Morrison 1981, Gratto 1988). Only small numbers of Semipalmated Sandpipers are known to migrate regularly through the southern coast of British Columbia during both spring and fall migration, and there is some suggestion that migration "strength" varies from year to year (Campbell et al. 1990). Thus, although some birds banded in Saskatchewan during fall migration have been observed in southern British Columbia, it is doubtful that this represents the normal migration route of most western breeders.

Data are few, but numbers of shorebirds migrating through the Quill Lakes area in spring do not appear to be consistent from year to year, even when habitat conditions seem favorable (Gratto-Trevor and Dickson, unpubl. data). We thought that in years of unfavorable water conditions at Cheyenne Bottoms, Kansas (a major interior spring staging site), larger numbers of shorebirds would stage at the Quill Lakes. This does not appear to be the case. Water conditions at Cheyenne Bottoms in spring 1988 were optimal, and upwards of 250,000 shorebirds were present (D. Helmers, pers. comm.). Over 150,000 birds were also seen that spring at Big Quill Lake (Morrison et al. 1991). In 1992, wetlands at Cheyenne Bottoms were dry until late May, and virtually no shorebirds were seen there that year (H. Hands, pers. comm.). Numbers at Big Quill Lake were also very low, even though suitable habitat was available (G. Beyersbergen, pers. comm.). It is possible that in some years, particularly when spring water levels in the interior of North America are unsuitable for foraging, Semipalmated Sandpipers are more likely to migrate along a broad front, spreading out over the prairies and into southern British





TABLE 3  
MEASUREMENTS OF SEMIPALMATED SANDPIPERS CAPTURED AT LITTLE QUILL LAKE,  
SASKATCHEWAN, FROM 1990 TO 1992

Season	Year	Age	N	Mean	SD	Range	CV
Wing (mm)							
Fall	1990	Adult	30	99.3	2.3	95-105	2.3
	1991	Adult	57	97.3	2.5	92-103	2.6
	1990	Juvenile	1309	98.2	2.3	91-106	2.3
	1991	Juvenile	491	99.0	2.3	92-105	2.3
Spring	1990	Adult	400	98.5	2.4	92-105	2.4
	1992	Adult	325	99.0	2.3	92-105	2.3
Bill (mm)							
Fall	1990	Adult	33	18.8	1.3	16.5-21.1	7.0
	1991	Adult	55	18.4	1.4	16.2-21.8	7.6
	1990	Juvenile	1175	18.5	1.2	15.0-22.5	6.5
	1991	Juvenile	485	18.7	1.2	15.7-22.0	6.4
Spring	1990	Adult	400	19.1	1.2	15.9-22.9	6.3
	1992	Adult	325	18.9	1.1	15.9-22.2	5.8

Columbia. For example, in the spring of 1989, the year fall migrants from LQL were seen in British Columbia, conditions for migrants at Cheyenne Bottoms were very poor (D. Helmers, pers. comm.).

Semipalmated Sandpipers have a cline in wing and bill length across their breeding range, with birds from the east averaging larger than those from the west. However, since wings and bills of females are on average larger than those of males in each population, measurements of western males and eastern females overlap greatly (Harrington and Morrison 1979, Godfrey 1986). In general, there was a greater average bill length of spring versus fall migrants at LQL (Table 3). The difference between spring and fall migrants was more pronounced using known-sex birds (Table 4), and indicates that at LQL spring flocks contain breeders from farther east than do fall flocks. This agrees with both the proposed elliptical migration and the sightings of LQL birds. Semipalmated Sandpipers migrating through LQL in the fall are most likely from western breeding areas. Spring mi-

FIG. 2. Observations of Semipalmated Sandpipers banded at Little Quill Lake, Saskatchewan, during fall migration. The banding site (July/August) is marked by a star. Birds observed during the fall or winter (July to March) are indicated by full triangles with point downwards, and those seen during spring or summer (April to June) by empty triangles pointing upwards.

TABLE 4  
MEASUREMENTS OF MALE AND FEMALE SEMIPALMATED SANDPIPERS  
COLLECTED AT LITTLE QUILL LAKE, SASKATCHEWAN FROM 1990 TO 1992

Season	Sex	N	Wing (mm)			Bill (mm)		
			Mean	SD	Range	Mean	SD	Range
Fall	Female	12	97.8	2.2	93-102	18.9	1.0	18.1-21.2
	Male	8	96.5	1.8	95-100	17.6	0.6	16.7-18.5
Spring	Female	5	100.0	2.3	97-102	20.0	0.6	19.0-20.6
	Male	8	96.9	2.4	95-101	18.1	0.9	16.7-19.1

grants appear to consist of a higher proportion of the larger central breeders, with some western birds also included (see Morrison 1984: Fig. 8). There was no seasonal difference in coefficients of variation, suggesting as much mixing of populations in spring as in fall, inconsistent proportions of each sex, or a greater variation in "western" breeders. With the information presently available, we cannot differentiate among these possibilities.

Hundreds of thousands of Semipalmated Sandpipers stage in the Bay of Fundy during fall migration, but almost none are present in the spring (Hicklin 1987). Ice gouging of mudflats and the lateness of spring in eastern Canada typically result in a paucity of food for shorebirds in the intertidal zone at that time of the year (Peer et al. 1986, Wilson 1989, P. W. Hicklin, pers. comm.). However, high invertebrate concentrations (primarily a burrowing amphipod, *Corophium volutator* L.) in the extensive mudflats of the Bay of Fundy in late summer (Peer et al. 1986, Mathews et al. 1992) attract large numbers of birds in the fall. This variation in food availability is thought to be a major factor influencing migration routes and elliptical migration in at least some populations of Semipalmated Sandpipers (Morrison 1984).

In conclusion, sightings of birds banded at Little Quill Lake, Saskatchewan, have confirmed the elliptical migration pattern of central Arctic breeding Semipalmated Sandpipers proposed in 1979 (Harrington and Morrison 1979). However, a number of individuals, probably western breeders, retrace their northward migration in the fall. Several birds banded in Saskatchewan in the fall were observed in southern British Columbia the following year. Nevertheless, due to the generally low numbers of Semipalmated Sandpipers seen on the west coast in the spring, and the timing of the Little Quill Lake sightings (very late spring or very early fall), it is unlikely to indicate a consistent pattern of elliptical migration by western breeders. Variation in "strength" of Semipalmated Sandpiper

migration on the west coast of Canada may result from variability in habitat suitability (due to drought) in the interior of North America. These results emphasize the inter-relatedness of staging sites in the western hemisphere for populations of Semipalmated Sandpipers. Negative impacts at a single important site could greatly affect a number of different populations of the species that use the area at different times of the year.

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